A Cloud Platform for Smart Government Services, using SDN networks: the case of study at Jalisco State in Mexico

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***Abstract*— This paper aims to describe the implemented platform, and the results with the use of applications in mobile devices for the payment of taxes reducing paperwork through cloud access platforms for government services used and, previously analyzed within a sensor network. We measure the flow of interconnected citizens in a private cloud infrastructure through SDN Networks. A solution is presented, integrating and setting the design requirements of a private cloud platform. Such requirements propose dynamic network bandwidth adaptation, security layers, and interoperability on IoT devices. We also conducted a literary review of existing platforms that are used to improve innovative technological implementations in Smart Cities. From that survey, we propose an architecture, and we continue with a comparative analysis of how this platform improves the services provided to citizens in the tax offices of the Jalisco State in Mexico. Finally, we conclude with the benefits provided for the smart government as part of a Smart Cities strategy.**

Keywords—Smart Cities, Cloud platform, Smart Government, SDN Networks, Cloud Environment.

I. INTRODUCTION

When the government improves services, the citizen's participation bound to implement innovative forms of governance in cities [1]. Smart Government is responsible for establishing an open dialogue between Smart City stakeholders and for proposing new methods of interaction [2]. Jalisco State will work in its transformation towards a Smart Government.

The first action is to work in the improvement of their IT infrastructure. Whit this will be able to install an IoT environment and at the same time offer to citizens online services for better access options in payment services, without deferral to run a review of public policies to upgrade the government services to Smart Government.

Current practices in the Smart Government offers city services in IT platforms supported by private cloud infrastructure [3]. Using Cloud Computing services help to better manage the integration of storage, processing, and resources in conventional data centers, making easier the assignment, management, and monitor of them [4].

Development of flexible and integrated cloud platforms is flourishing, is necessary to model the requirements for its implementation and maintenance [5]. The implementation of the Internet of Things (IoT) encourages the recollection and generation of information for the development of processes and information able to improve the services used by the citizens[6].

The data decoupling provided by Software Defined Networks (SDN) provides independent flexibility of the hardware, adopted in the development of cloud platforms and provides dynamic reconfiguration to improve data network robustness [7]. In the next section, we will cover more details on SDN.

Citizens and companies expect the government to reduce costs and improve the efficiency of its offices and services, allowing greater administrative transparency, provision of electronic government services, and quality of service. Due to this, many governments seek to establish governmental clouds supporting more efficient public services and improving better the accountability of the regional economy. Some governments have established complete governance clouds with the integration and effective management of the infrastructure of their data centers having a successful digital transformation, providing reliable government services for public and private sector [4]. This situation motivates the Jalisco state government to start the development of its cloud to host its services.

Some challenges for governments to implement cloud services are legislation, trust controls, protocols to information management, among others. In present work, we focus on the

implementation of network infrastructure in a cloud to provide some government services for society, specifically for the tax payment.

In this paper, we introduce the Jalisco private cloud that enables quick access to light but robust services using mobile devices.

In next section, we present the elements that make up our platform in addition to some works about platforms that incorporate cloud tools with SDN networks to solve specific problems. The third section presents some of the problems that make necessary to define clouds platforms for the implementation of government services through Apps for the Jalisco Smart Government. Subsequently, we present the cloud platform that incorporates SDN architecture with OpenStack. For the fifth part of our document, we describe the cloud implementation with the Apps, making a brief analysis of the results and benefits obtained. We finish with the conclusions and present the future works.

II. ELEMENTS OF THE PLATFORM AND RELATED WORKS

This section presents principal elements of our platform and some works relevant to cloud platforms for smart environments.

A. Elements of the platform

1) Software Defined Networks, SDN

SDN is an emerging technology that eliminates the intelligence of network devices and, gives its functions to a centralized device. Its basic structure consists of three layers: infrastructure layer, control layer, and application layer [8].

Infrastructure layer is conforming by routers, switches, and access points. Its primary function is to forward packets based on assigned rules and policies. Control layer relays on a central device that controls the SDN functions; it is a mediator between the infrastructure and the application layer. Application layer is responsible for the security and commercial applications related to the software. Some examples are network virtualization, intrusion detection, and prevention systems (IDS, IPS), firewall, among the most important. This software layer communicates with the control layer through the application interface

SDN can enhance Cloud scenarios. Thanks to SDN, it is possible to achieve interconnection of networks between virtual machines (VM's) this can be from one or several cloud providers managed by different administrative domains [9].

2) Virtualization

Virtualization is a tool that eliminates a large number of existing inefficiencies in the provisioning of computing resources [10]. A virtual machine is an isolated container software that runs its operating system and applications as if it were a physical computer [11].

Doherty [10] explains how we can obtain significant benefits by virtualizing the entire network infrastructure and how virtualization is the basis of development of Software Defined Networks (SDN). Virtualization is a concept that leads us to consolidate the concept of "the cloud" and SDN.

Hence, as a first step, the Government of Jalisco State made Virtualization of its servers in order to implement the architecture of an SDN network in its offices.

3) OpenStack

OpenStack is a cloud operating system that controls large groups of computing resources, storage, and networks between data centers managed through an API or panel. It works with enterprise and open source technologies, ideal for complex infrastructures [12]. Is used as a platform for construction of a cloud, it has the aim of being able to scale quickly, make the fault management more efficient, provide redundancy and high availability [10]. OpenStack provides Cloud Infrastructure as a Service (IaaS) consisting of a group of specific services that cooperate to generate new functions. The platform provides processing, storage, and network resources[9].

Some of these services are Nova (processing service), Neutron (networking service), Keystone (identity service), and Glance (image service) [12], [13].

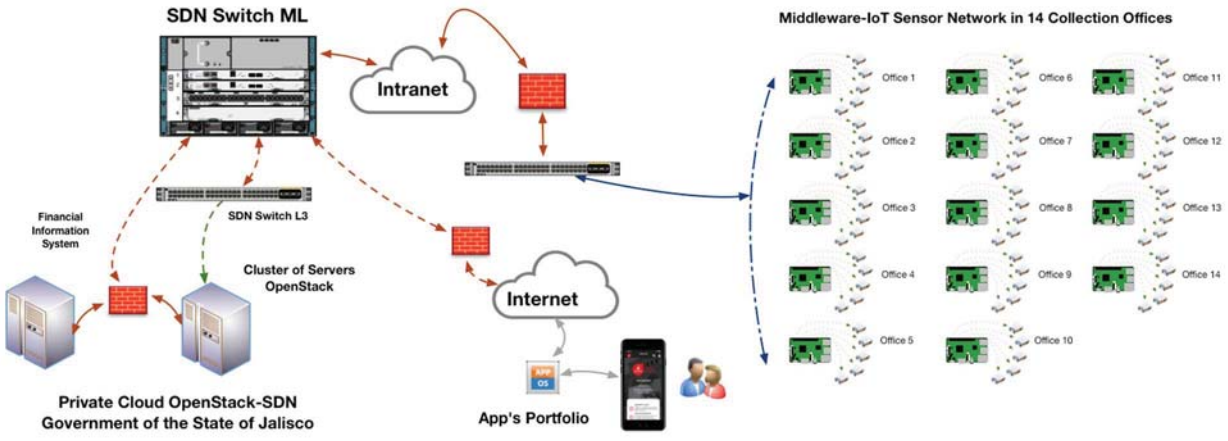

Fig. 1. Cloud platform for Government Services with OpenStack and SDN for services and sensors in government offices.

B. Related works

1) Architecture SDN for the incorporation of Cloud Service using OpenStack

A Smart Government must deliver services that be able to integrate, coordinate, and automated architectures multi-systems [3]. In order to offer these multi-services this article proposed a technique for monitoring online services. The implementation of an SDN Architecture for incorporation of Cloud Service using OpenStack, migrating tax payment services is presented. Concludes with a comparison between the sessions established before and after the migration, observing an increase of more than 100% of sessions. It is concluded that the implemented architecture improves the user experience. [14].

2) Enhance Network Communications in a Cloud-based Real-time Health Analytics Platform Using SDN

This article presents the Artemis platform; Artemis assumes there are different ways to deliver data in real time. The technique implemented by the author is to replace conventional routing with SDN rules to guarantee real-time deliveries[5]. With this implementation it is demonstrated that the smaller route of conventional protocols is less efficient than the route provided by SDN. With the routing technique with SDN, route selection is guaranteed with minimum packet loss.

3) Comprehensive Management Platform for Smart Cities

Shahrour et al. present an integral platform that guarantees security, efficiency, and performance in some tasks of the Smart Cities, for the SunRise City project of the Civil engineering and geo-environmental laboratory in Lille at the north of France [18]. The technique they implement is in five stages: first, Data collection, second, Data storage, thirdly Data analysis and system management to continue with Data display and visualization ending with User Interface, Stakeholders'' interaction. [15].

In this work, we focus on *data recollection area*, and there is a platform that is used to make its recollection. It is necessary to consider that the data proceed from different sources (sensors, IoT devices, cameras, social networks, weather, or other sources) and required a secure, resilient and reliable environment that allows lost data recovery.

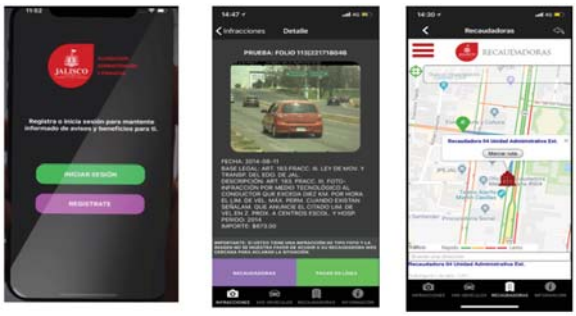

Fig. 2 View of the "InfraJal Plus" App

III. Government Problems

Jalisco state has an extension of 78,588 kilometers and has 125 municipalities [19] whit 136 collection offices distributed among all of the municipalities [20]. This dimension makes complex to gather the Data generated.

The collection of taxes and the massive influx of users to the collection offices generate a problem reflected in the investment of time in moved and waiting for lines of citizens to be able to meet their tax obligations [14]. Besides, in the area responsible for generating photographic infractions, there is an excellent delay in notifies the incidents to the citizens. For this reason, many drivers with surcharges have penalties for not paying the amount of the sanction derived from these tickets. By implementing technological tools, we solve the problems with the implementation of technological tool converging towards an efficient Cloud platform.

The purpose of implementing cloud computing is to be able to integrate storage, computing capacity, and processing resources into a single IT infrastructure. This infrastructure must be able to assign, manage and monitor the government's computer services in order to provide answers and real-time access in a practical, collaborative and high-performance manner to have a service-oriented government [4]. Currently, governments have the infrastructure in their data centers. To build a cloud, governments must make the most of this infrastructure, seeking full and optimal integration [4].

The cloud services must include Networks Virtualization technologies, to start with the Software Defined Networks (SDN) to improve efficiency in the decision process at the Smart City [18], [19]. We use OpenStack to build the Virtual Machines and the SDN network that makes up our Cloud platform.

IV. Cloud Platform, using SDN with OpenStack for Government Services

In this section, we present our Cloud platform implemented in Jalisco State Government and the InfraJal Plus App to become a reference for any Latin American Government to incorporate Cloud services for its citizens. We continue with a comparative analysis of how this platform improves the services provided to citizens in the tax offices of the Government of Jalisco State.

The design of our Cloud platform considers the current infrastructure for its installation, seeking the optimization of resources through the virtualization of equipment and services using NFV. We develop an infrastructure for data transfer with SDN on Open Stack. This cloud platform will be used to assemble the applications that will serve the citizens; in addition to carrying out the compilation of data from the IoT devices installed in the collection agencies to feed information to the implemented applications.

In Fig. 1 its present the Cloud platform for Government services, the distribution processes in the private cloud with OpenStack through the SDN policies. The cloud is built over OpenStack and using Neutron service; the SDN network was ability. Over this cloud had installed virtual machines that contain the Databases with the financial information system, the collection about photographic infractions, among others. This cloud interacts with the Middleware-IoT sensors installed in the Collection Offices, feeding to the database.

The Cloud provides the applications the number of people who are physically in these offices, the infractions generated by some camera in the system.

We use photo-street sensors, regarding notification of the photo-street sensors that were informed up to three or several months after infringing. To notify to the citizen its vehicular situation it was developed of the App called InfraJal (Fig. 2) was initially put into operation within the virtual platform of private OpenStack to perform performance tests, with the use of SDN itself that allowed prioritizing data traffic. With this, we achieve that the process of attending the concurrent requests be efficient. Moreover, we can classify with priorities the traces of the most important packages to the centralized databases.

Fig. 2, shows the images of the InfraJal Plus App,

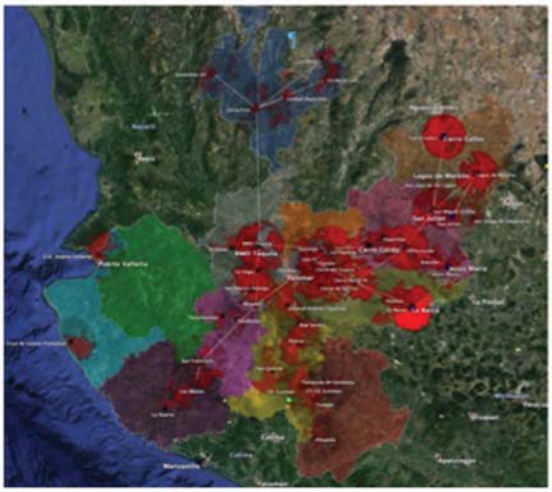

Fig.3 Integration Model of the Jalisco State Network

displaying information in real time of the vehicle unit, in this case, the citizen has options to make the payment either online or in the collection agency. The App reports the status of the Collection Office, its location, if it is open or closed, even the saturation of citizens. The saturation of citizens is obtained as a result of the analysis of the recollected data of the sensors located in the offices and foresee their displacement if it is an advisable option.

Exist a project to provide better coverage of Internet services in the State of Jalisco, Jalisco State Network project for Internet access [20]. Intends to interconnect the entire Metropolitan Area of Guadalajara and the municipal capitals by fiber optic. With this approach, the government aims to consolidate the current wireless infrastructure. With proper Wireless infrastructure, it will allow the governments of any municipality to interconnect and use the cloud platforms, including the integration of consumption of databases and Apps distributed in the private cloud developed by the Metropolitan Government. With it, the integration of devices that collect data through sensors, we use the flow of services to develop new centralized applications. The goal is to articulate all governments with a single investment making to consolidate a Smart government more efficient in both spending and avoiding displacement of the user to government offices, see fig. 3, it presents the model integration of the Jalisco state network.

Información sobre dispositivo móvil	Adquisición		
	Usuarios	Usuarios nuevos	Sesiones
	627.423 % del total: 46,87 % (1.338.591)	586.748 % del total: 47,54 % (1.234.178)	1.367.397 % del total: 43,03 % (3.177.560)
1. Apple iPhone	135.050 (21,58 %)	127.515 (21,73 %)	266.387 (19,48 %)
2. (not set)	44.241 (7,07 %)	42.465 (7,24 %)	97.544 (7,13 %)
3. Samsung SM-G532M Galaxy J2 Prime	17.259 (2,76 %)	16.608 (2,83 %)	33.008 (2,41 %)
4. Apple iPad	13.014 (2,08 %)	12.498 (2,13 %)	21.928 (1,60 %)
5. Motorola Moto G (5) Plus	10.393 (1,66 %)	9.459 (1,61 %)	25.695 (1,88 %)
6. Huawei ANE-LX3 P20 Lite	9.400 (1,50 %)	9.222 (1,57 %)	21.757 (1,59 %)
7. Samsung SM-J700M Galaxy J7 2015	9.232 (1,48 %)	8.478 (1,44 %)	21.332 (1,56 %)
8. Samsung SM-G610M J7 Prime	8.993 (1,44 %)	8.438 (1,44 %)	22.749 (1,66 %)
9. Samsung SM-G531H Galaxy Grand Prime	8.826 (1,41 %)	8.246 (1,41 %)	18.468 (1,35 %)
10. Motorola Moto E(4)	8.666 (1,38 %)	8.107 (1,38 %)	19.600 (1,43 %)

Table 1, Mobile device ratio number of users from September 1, 2018, to June 9, 2019.

V. PLATFORM IMPLEMENTATION AND RESULTS

The consolidation of the private cloud by prioritizing traffic with SDN has also enabled the number of sensors to grow in the primary revenue areas of the Government of the State of Jalisco both in the Metropolitan Area of Guadalajara and in government offices in the interior. Have increased the number of services of fast access to light platforms employing Apps in the leading stores for mobile devices like Apple Store and Google Play. In Table1, the relation of devices and users that use the Government Apps is detailed [18]. Fig. 4 shows the traffic of mobile devices and tablets by region in the period from September 1, 2018, to June 6, 2019, where the deployment of the service is with global visibility in the network. Also, another area of growth was the deployment of 70 sensors in 14 Metropolitan offices (five motion sensors per collector) integrated into the private Cloud platform OpenStack-SDN. We connect these sensors through a network, moving the data with IoT controllers based in a Raspberry pi3 middleware using MQTT as a communications protocol. This controller allows measuring the flow of users per collector office by sending data to the App itself, which allows informing in real time the flow of taxpayers. With this information, the App user can know the number of people who are in the offices before their displacement and get the opportunity to pay online securely, see fig. 5, which represents the number of movements by the 14 distributed in the Guadalajara metropolitan area tax collector centers from September 1, 2018, to June 6, 2019.

Fig. 2 Mobile and tablet traffic by the use of online services

As a result of data collected from sensors and in correlation with data from tax payment transactions, today, a mobile application is in the process of development with access to an elastic private cloud. Fourteen offices represent 10% of the 11 offices in the State of Jalisco, where we can achieve more efficiency and better productivity when the mobile app will be launched and prepared for the peaks of service demand. Besides, the IoT sensors were not only useful to model the migration of physical tax payments to electronic services in mobile apps. Also, understanding the flows and behaviors of citizens in public buildings helps to model how to save energy. We are learning with the models when we need to activate the Air Conditioning Systems in different buildings, or when it is more convenient to provide building maintenance in compromise with productivity. Since the systems are distributed to monitor different physical locations in the city, we also are realizing how to monitor overall energy consumption in different government offices and how to reduce it.

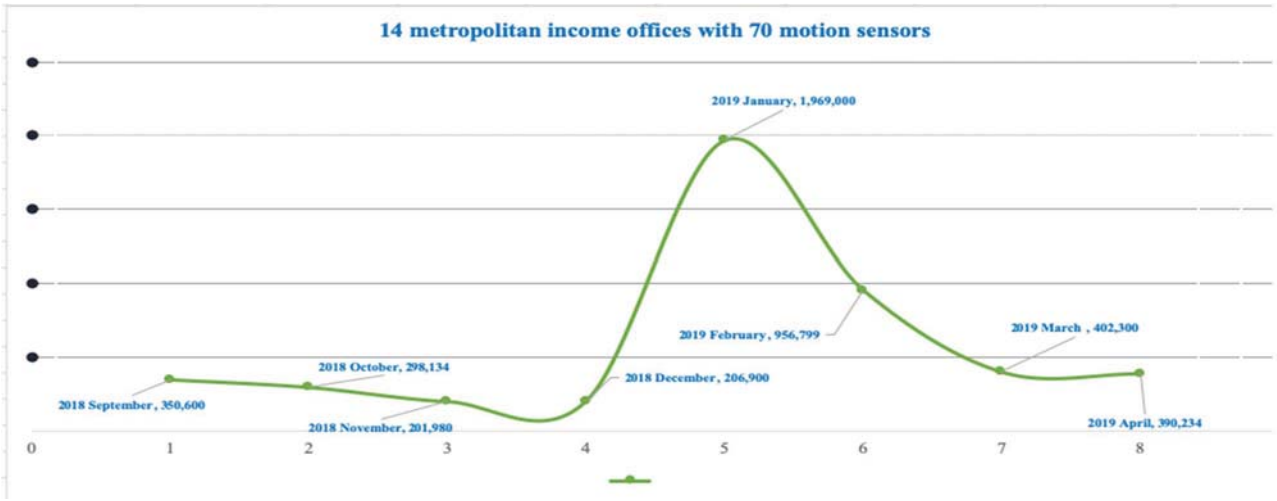

Fig. 1, 70 Movement sensors deployed in 14 collection offices.

VI. Concluding Remarks and Perspectives

The proposed research work proposes to use private cloud platforms using SDN with OpenStack in the government sector. This strategy protects the information of citizens within the government and has a more rational use of available IT infrastructure for city services. For instance, a discussion around the use of public clouds to keep citizens data and processes is still under review.

In Mexico and other Latin American countries, IT models are implemented in private clouds to provide city services. Such services need to be modeled to understand better how to implement elasticity and provide a better quality of service. The project shown in this paper uses IoT presence sensors to model demand over time in tax offices. Such demand helps to prepare elasticity in private clouds and migration to digital portals to replace physical offices soon.

Also, with the private cloud, the use of SDN networks allows to optimize the use of data flows and improve security. At the same time, as tax transactions were processed, a set of IoT sensors were using the same network collecting data of citizens behavior on queues to correlate efficiency in processes. The IOT devices were deployed and tested to model queues flows from January to April 2019 in 14 tax offices in the metropolitan area of Guadalajara. We successfully implemented a distributed architecture dealing with resiliency for IoT devices.

Finally, as a cooperation between the University of Guadalajara and the Jalisco State Government, this is the second publication as a result of this collaboration; to help the process of Guadalajara city and Jalisco State advancing to become a territory of fully implemented Smart Cities.

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